Rangeland Soil Quality

National Park Service
U.S. Department of the Interior

Natural Resources Program Center
Geologic Resources Division

Organic Matter

Soil organic matter is carbon- rich material that includes plant, animal, and microbial residue in various stages of decomposition. Live soil organisms and plant roots are part of the carbon pool in soil but are not considered soil organic matter until they die and begin to decay. The quantity and composition of soil organic matter vary significantly among major ecosystems. Soil in arid, semiarid, and hot, humid regions commonly has less organic matter than soil in other environments. The total content of organic matter ranges from less than 0.5 to more than 8 percent in the surface layer of rangeland soils. Soil organic matter includes three main components (table 1). The light fraction is more biologically active than the other two and includes relatively fresh plant fragments. Physically protected organic matter is locked within aggregates of mineral particles, where it is protected from microbial decomposition. Chemically stable organic matter gives soil its dark color and is generally the largest pool of organic matter in soil. Physically protected organic matter may also be chemically stable.

Why is organic matter important?

Soil organic matter enhances soil functions and environmental quality because it:

- binds soil particles together into stable aggregates, thus improving porosity, infiltration, and root penetration and reducing runoff and erosion;
- enhances soil fertility and plant productivity by improving the ability of the soil to store and supply nutrients, water, and air;
- provides habitat and food for soil organisms;
- sequesters carbon from the atmosphere;
- reduces mineral crust formation and runoff; and
- reduces the negative water quality and environmental effects of pesticides, heavy metals, and other pollutants by actively trapping or transforming them.

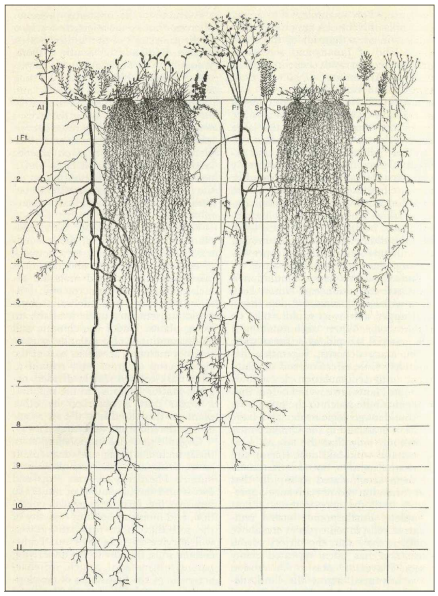
Table 1.—Soil organic matter

Component	Rate of decay	Primary function
Light fraction	Weeks to months	• Serves as food for soil organisms • Stores and provides plant nutrients
Physically protected	Decades	• Enhances soil structure, porosity, and the water-holding capacity
Chemically stable	Hundreds to thousands of years	• Holds nutrients • Stabilizes microaggregates

What affects soil organic matter?

The amount of organic matter in the soil is a balance between additions of plant and animal materials and losses through decomposition and erosion.

Environmental factors interacting over time affect the amount of organic matter in soil. Rainfall and temperature affect plant productivity and the rate of organic matter decomposition. Increasing levels of organic matter promote a higher waterholding capacity, which results in increased plant growth and thus an increased amount of organic matter and plant nutrients.



Roots are the primary source of organic matter. Dead roots and gelatinous materials exuded by plant roots as they grow through the soil are decomposed by soil organisms and converted into organic matter. Since much of what is produced above ground is lost through photo oxidation, the amount of root production is very important. Every year, about 25 percent of the total root biomass in areas of tall prairie grasses dies and becomes available for incorporation into the soil as organic matter. In the drier areas, such as areas of short prairie grasses, about 50 percent of the root biomass becomes available, but the total amount is less than that in the areas of tall grasses.

Plant composition and distribution control the distribution of organic matter. The horizontal and depth distribution of roots, the distribution of plants across the landscape, and the susceptibility of roots to decay vary among species. The roots of forbs and shrubs generally contribute less organic matter to the surface layer of the soil than the roots of grasses. Changes in the composition of plant species, especially from grasses to shrubs, affect the contribution of roots to soil organic matter. The organic matter is enhanced by litter beneath shrubs in areas of arid and semiarid rangeland. Fire initially reduces the amount of plant residue added to the soil. If the fire results in a shift from shrubs to grasses, however, the long-term effect can be an increase in soil stability and organic matter.

Soil organisms break down litter, dead roots, and organic matter into smaller fragments and compounds. As they decompose organic matter, they convert nutrients into plant- available forms and release carbon dioxide into the atmosphere. Warm, moist soil supports higher decomposition rates than waterlogged, dry, or cool soil.

Wind erosion and water erosion increase losses of organic matter. Erosion breaks down soil aggregates, exposing physically protected organic matter to decomposition and loss. Organic- rich soil from the surface layer is carried away by runoff or wind. Litter redistribution by wind or water from or to surrounding rangeland also affects the content of organic matter.

Grazing can change plant composition and distribution and increase or decrease the amount of organic matter in the soil. Grazing can increase the rate of root turnover, but overgrazing reduces the amount of plant energy available for the growth of new roots. Trampling by livestock can help to incorporate the plant material above the ground into the soil. In arid ecosystems, however, little plant material is available for incorporation. Trampling also breaks up soil aggregates, exposing organic matter to decomposition and loss through erosion.

Management Strategies

The following strategies can help to maintain the optimum content of organic matter in rangeland soils:

- Increase or maintain plant production.
- Promote the growth of species with high root production and promote a mix of species with different rooting depths and patterns.
- Promote the incorporation of above- ground plant material in moist plant communities with large amounts of standing plant material (e.g., areas of tall prairie grasses).
- Protect the soil from erosion by maintaining or increasing the plant cover and reducing the amount of bare soil.
- Properly manage grazing, fire, and vehicle use and thus promote the desired plant community and protect the soil from erosion.

For More Information

Pete Biggam
Soils Program Coordinator
303- 987- 6948
pete_biggam@nps.gov

More information can also be found on the Soils website at: www2.nature.nps.gov/geology/soils

The National Park Service, Soil Inventory and Monitoring Program is partnering with the USDA-Natural Resources Conservation Service, and the USDA Agricultural Research Service, Jornada Experimental Range, to develop a series of assessment and monitoring protocols to assist NPS Vital Signs Monitoring Networks in understanding and evaluating the important role soils play within ecosystems.